**8.3 Destruction From Earthquakes**

The Good Friday Alaskan Earthquake in 1964 was the most violent earthquake to jar North America in the 20th century. The earthquake was felt throughout Alaska. It had a moment magnitude of 9.2 and lasted 3 to 4 minutes. The quake left 131 people dead and thousands homeless. The state’s economy was also badly damaged because the quake affected major ports and towns. Had the schools and businesses been open on this holiday, the death toll would surely have been much higher.



**Seismic Vibrations**

The 1964 Alaskan earthquake gave geologists new insights into the role of ground shaking as a destructive force. **The damage to buildings and other structures from earthquake waves depends on several factors. These factors include the intensity and duration of the vibrations, the nature of the material on which the structure is built, and the design of the structure.**

**Building Design**

All multistory buildings in Anchorage, Alaska, were damaged by the vibrations. However, the more flexible wood-frame buildings, such as homes, were less damaged. Figure 10 offers an example of how differences in construction can affect earthquake damage. You can see that the steel-frame building on the left withstood the vibrations. However, the poorly designed building on the right was badly damaged. Engineers have learned that unreinforced stone or brick buildings are the most serious safety threats during earthquakes.

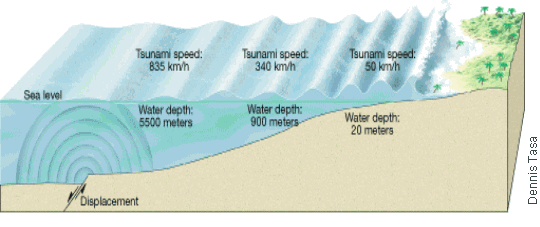
**Liquefaction**

Where loosely consolidated sediments are saturated with water, earthquakes can cause a process known as [**liquefaction**](javascript:openGlossaryWnd('e_ga_06_liquefaction')). Under these conditions, what had been stable soil turns into a liquid that is not able to support buildings or other structures. Buildings and bridges may settle and collapse. Underground storage tanks and sewer lines may float toward the surface.

**Tsunamis**

Most deaths associated with the 1964 Alaskan quake were caused by seismic sea waves, or [**tsunamis**](javascript:openGlossaryWnd('e_ga_06_tsunami')). These destructive waves often are called tidal waves by news reporters. However, this name is incorrect because these waves are not produced by the tidal effect of the moon or sun.

**Causes of Tsunamis**

**A tsunami triggered by an earthquake occurs where a slab of the ocean floor is displaced vertically along a fault. A tsunami also can occur when the vibration of a quake sets an underwater landslide into motion.** Once formed, a tsunami resembles the ripples created when a pebble is dropped into a pond. A tsunami travels across the ocean at speeds of 500 to 950 kilometers per hour. Despite this speed, a tsunami in the open ocean can pass without notice because its height is usually less than 1 meter, and the distance between wave crests can range from 100 to 700 kilometers. However, when the wave enters shallower coastal water, the waves are slowed and the water begins to pile up to heights that sometimes are greater than 30 meters, as shown in Figure 11.

**Figure 11 Movement of a Tsunami** A tsunami is generated by movement of the ocean floor. The speed of a wave moving across the ocean is related to the ocean depth. Waves moving in deep water travel more than 800 kilometers per hour. Speed gradually slows to 50 kilometers per hour at depths of 20 meters. As waves slow down in shallow water, they grow in height until they topple and hit shore with tremendous force.

**Q** What is the largest wave triggered by an earthquake?

**A** The largest wave ever recorded occurred in Lituya Bay, about 200 kilometers west of Juneau, Alaska. On July 9, 1958, an earthquake triggered an enormous rockslide that dumped 90 million tons of rock into the upper part of the bay. The rockslide created a huge splash wave that swept over the ridge facing the rockslide. The splash uprooted or snapped off trees 522 meters above the bay. Even larger splash waves may have occurred 65 million years ago when an estimated 900-meter wave is thought to have resulted from a meteorite impact in the Gulf of Mexico.

**Tsunami Warning System**

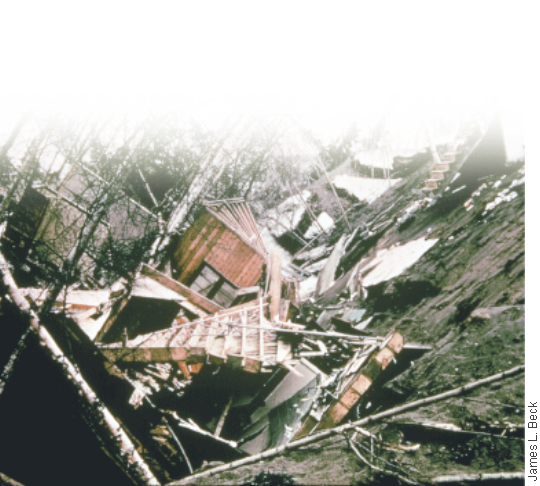
The destruction from a large tsunami in the Hawaiian Islands led to the creation of a tsunami warning system for coastal areas of the Pacific. Large earthquakes are reported to the Tsunami Warning Center in Honolulu from seismic stations around the Pacific. Scientists use water levels in tidal gauges to determine whether a tsunami has formed. Within an hour of the reports, a warning is issued. Although tsunamis travel very rapidly, there is sufficient time to evacuate all but the area closest to the epicenter. Fortunately, most earthquakes do not generate tsunamis. On the average, only one or two destructive tsunamis are generated worldwide every year. Only about one tsunami in every 10 years causes major damage and loss of life.

**Other Dangers**

The vibrations from earthquakes cause other dangers, including landslides, ground subsidence, and fires.

**Landslides**

**With many earthquakes, the greatest damage to structures is from landslides and ground subsidence, or the sinking of the ground triggered by the vibrations.** The violent shaking of an earthquake can cause the soil and rock on slopes to fail, resulting in landslides. Figure 12 shows some of the damage landslides can cause. Earthquake vibration can also cause large sections of the ground to collapse, liquefy, or subside. Ground subsidence can cause foundations to collapse, as shown in Figure 12. It can also rupture gas and water pipelines.



**Figure 12** This landslide caused by the 1964 Alaskan earthquake destroyed many homes. More than 200 acres of land slid toward the ocean. **Interpreting Photos** Assuming the land was originally horizontal, to what angle have the trees on the left side of the photo been tilted?

**Fire**

The 1906 San Francisco earthquake reminds us of the major threat of fire. The city contained mostly large wooden structures and brick buildings. The greatest destruction was caused by fires that started when gas and electrical lines were cut. Many of the city’s water lines had also been broken by the quake, which meant that the fires couldn’t be stopped. A 1923 earthquake in Japan caused an estimated 250 fires. They devastated the city of Yokohama and destroyed more than half the homes in Tokyo. The fires spread quickly due to unusually high winds. More than 100,000 people died in the fires.

**Predicting Earthquakes**

The earthquake in Northridge, California, in 1994 caused 57 deaths and about $40 billion in damage. Scientists warn that quakes of similar or greater strength will occur. But can earthquakes be predicted?

**Short-Range Predictions**

The goal of short-range prediction is to provide an early warning of the location and magnitude of a large earthquake. Researchers monitor possible precursors—things that precede and may warn of a future earthquake. They measure uplift, subsidence, and strain in the rocks near active faults. They measure water levels and pressures in wells. Radon gas emissions from fractures and small changes in the electromagnetic properties of rocks are also monitored. **So far, methods for short-range predictions of earthquakes have not been successful.**

**Long-Range Forecasts**

Long-range forecasts give the probability of a certain magnitude earthquake occurring within 30 to 100-plus years. These data are important for updating building codes, which have standards for designing earthquake-resistant structures. Long-range forecasts are based on the idea that earthquakes are repetitive or cyclical. In other words, as soon as one earthquake is over, the forces in Earth will begin to build strain in the rocks again. Eventually the rocks will slip again, causing another earthquake. Scientists study historical records of earthquakes to see if there are any patterns of recurrence. They also study seismic gaps. A [**seismic gap**](javascript:openGlossaryWnd('e_ga_06_seismicgap')) is an area along a fault where there has not been any earthquake activity for a long period of time. There has been only limited success in long-term forecasting. **Scientists don’t yet understand enough about how and where earthquakes will occur to make accurate long-term predictions.**

**SECTION 8.3 Destruction from Earthquakes Assessment**

**Reviewing Concepts**

(1) What destructive events can be triggered by an earthquake?

(2) What physical changes have been used in the attempts to predict earthquakes?

(3) What is a tsunami?

(4) What is a seismic gap?

**Critical Thinking**

(5) **Making Judgments** Do you think scientists are close to being able to accurately predict earthquakes? Explain your answer.

(6) **Drawing Conclusions** Why is it incorrect to refer to tsunamis as tidal waves?

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